

## PALMYRA AS IT ONCE WAS: 3D VIRTUAL RECONSTRUCTION AND VISUALIZATION OF AN IRREPLACABLE LOST TREASURE

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### ABSTRACT:

Palmyra was a mosaic which was composed through its colourful past, by Assyrians, Parthians, Greeks and Romans. For centuries, the spectacular ruins and impressive panorama of the antique city used to captivate and inspire the visitors as the witnesses of its illustrious history. As a grim consequence of the horrific conflict that engulfed Syria, since May 2015 they are no more to be seen. Palmyra has been purposely targeted and obliterated, the ruins have been reduced to rubble. The immense beauty and rich heritage of Palmyra which has been lost forever is reconstructed here as it was once was, at the top of its glory, with the hope of preserving its memory.

### 1. INTRODUCTION

Palmyra was among of the most impressive ancient cities (like Pompeii and Ephesus) which were ever brought to light. This most impressive ruined city of the middle-east lay in the heart of a huge oasis in the Syrian desert. Surrounded by palm groves, two mountain ranges, and a pleasant stream, the ancient city of Palmyra had the aura of myth. It had long been recognized as one of the most famous testimonies of antiquity, and has been a UNESCO World Heritage site since 1980.

This city occupied a historically significant and culturally important position of incomparable value. Palmyra bore the traces of caravan routes that testified its role as a corridor of the west-east trade. Hundreds of meters of colonnaded streets, imposing temples and a vast necropolis used to be the extant manifestations of the richness of Palmyra, which took place in the 2<sup>nd</sup> and 3<sup>rd</sup> centuries. A tetrapylon marked and highlighted where the heart of the city had once beaten. Situated at the skirts of the mountain range was a huge necropolis whose murals and expressive portrait paintings reflected the prosperity of the merchant class of the city.

Since it lay geographically on a favorable old caravan road between Rome and the Persian Gulf, Palmyra's wealth was based on commerce. It was an interface between Orient and Occident, a place of cultural encounters and blending. With the legendary Queen Zenobia around AD 270 Palmyra had a last, brilliant climax, but the glamour of the city did not last long: the war waged between Queen Zenobia and Emperor Aurelian proclaimed the end of the caravan metropolis, and resulted in the pillage of the city. Material evidence from the Byzantine and Muslim periods insinuated that the city was still populated for a long time, but it had never returned to the old bright days.

The cultural significance of Palmyra, which was so rich in archaeological remnants that melded the west with the east made it the primary target of terrorist assault. The effect of the destruction of ISIS since May 2015 was all the more devastating.

Whatever had been created and cultivated since those memorable years of Palmyrene wealth and Roman might have been blown up. Today, we can revive and appreciate the majesty of Palmyra only through its reconstruction and this work aims at offering a glimpse of Palmyra as it once was.

### 2. A MONUMENTAL ANTIQUE CITY IN THE DESERT

This caravan city of the desert accomplished impressive growth from the 1<sup>st</sup> century BC to the 3<sup>rd</sup> century AD and fulfilled its development as a regional power at junction of the perimeters of the Roman and Parthian/ Sasanian Empires. This coexistence gave rise to a unique identity which was forged by blending Greco-Roman culture with Iranian–Arabic elements.



Fig.1 The oasis of Palmyra is situated in Syrian Desert

The oasis of Palmyra is situated in Syrian Desert, 200 kilometres to the north-east of Damascus and 230 kilometres to the west of the banks of Euphrates (Fig. 1). In order to get to Palmyra, before the summer of 2015, visitors ought to fly from a major city in Europe to Damascus first. It took approximately four hours from Paris and five hours from London. The second leg of the journey

continued on land for another four hours along an asphalted road which followed the ancient route. After four hours of journey through the desert, the visitors were amazed and astonished by the sight of the immense remnants of a lost antique civilization (Veyne, 2016).

Palmyra's rise to a cosmopolitan centre would be totally obscure were it not for these monumental ruins. The captivating scenery comprised a number of temples, hundreds of metres of white colonnaded streets, a Roman theatre, a citadel, and an agora in addition to innumerable tomb towers, plus an ancient city wall encircling a major part of them. The green palm grove completed the composition of white and golden yellow colours. Palmyra was a site of outstanding value from aesthetic, cultural and historical points of view.

Palmyra had remained for many years to European audiences as simply a caravan city of legend. As early as 1753, such a glimpse of the magnificence of this city was brought before the eyes of an audience devoted to orientalism and antiquities, by Dawkins and Wood. The antique city had remained for hundreds of years partly visible and partly buried under sands of Syrian desert, waiting for being rediscovered. Subsequent to his travel to the site with his friend Dawkins, Wood was the first to revive Palmyra in his book *The Ruins of Palmyra, otherwise Tedmor, in the Desert* (Wood, 1753). With this publication of Wood, and thanks to Giovanni Battista Borra's drawings, the main repository of information as regards to graphical data had been available. These drawings, a little devoid of fancy, but relatively exact, were succeeded by others, more extravagant, due to Louis Francois Cassas (1799). Subsequently with the advent of photography, photos taken between 1867 and 1876 by Felix Bonfils provided the most complete visual record of Palmyra from the 19th century.

It was after the first truly scientific surveys were carried out by two German expeditions, one directed in 1902 by O. Puchstein, the other in 1917 by Theodor Wiegand, another indispensable information source appeared: *Palmyra: Ergebnisse der Expeditionen von 1902 und 1917* (Wiegand, 1932). Finally, with the 1972 publication of Seyrig, Amy and Will about the most important monument of Palmyra, *Le Temple de Bel a Palmyre*, almost everything we need to know for the restitution Palmyra was at hand.

With inspiration derived from these sources, and encouragement from the advances of computer graphics technology in recreating ancient worlds (Forte and Siliotti, 1997), modelling and reconstruction of the ruins of Palmyra had been the subject of a recent book: *Reviving Palmyra in Multiple Dimensions: Images, Ruins and Cultural Memory*. This book which was co-authored by the author together with M. Silver and G. Fanni provides a virtual reconstruction of Palmyra with the aim of lifting it from its ruins (Minna et al, 2017). In a preceding work the author had presented the earlier model of the city (Denker, 2016). It was followed by a work focussed to the most significant landmark of Palmyra: Temple of Bel (Denker, 2017).

### 3. 3D RECONSTRUCTION OF THE CITY

In what follows, the stages of reviving the city are presented with the objective of a more detailed and comprehensive reconstruction. Less known temples of the city like temples of Allat and Nabu and other significant buildings like Diocletian Camp and Diocletian Bath are also included.

#### 3.1 The City Walls and the Citadel

A vast circuit of walls surrounds Palmyra. The city is first and foremost defined by them. The boundary between the urban core and the surrounding desert is drawn by these walls and the oasis. Although the circuit of walls constituted the most expensive of the monuments Palmyra had, Palmyrenes had strived to acquire this costly structure, since it signified the autonomy of them, as well as helped defend the city. The circuit of the city walls was completed during the reign of Zenobia and was in use in defending the city against Aurelian's army. The wall was built of the local material, mud bricks were laid upon stone foundations. The wall had a modest height of 2 metres. It followed on the southern edge the wadi and ran along the stream which skirted the Temple of Bel (Fig. 2).

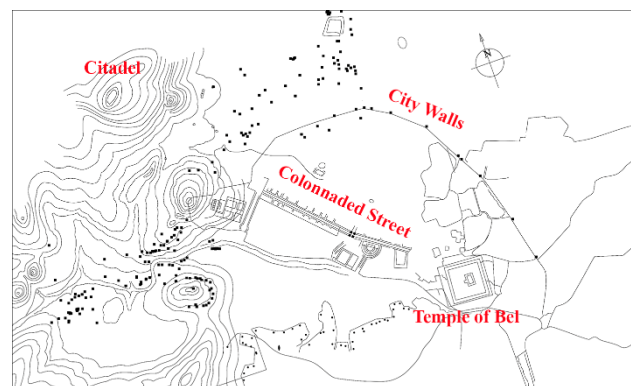


Figure.2 City plan and the circuit of the city walls of Palmyra

The city walls and enclosed ancient ruins of Palmyra can be best seen from the citadel which is also known as Qalaat Shirkuh. Fakhr-al-Din al-Ma'ani Castle was built on this stunning location in AD 13<sup>th</sup> century by Mamluks on a commanding position of a high hill to the west side of the city. Because of its strategic position it had been a main target by jihadists and suffered significant damage consequently. The picturesque view as used to be seen from the mountaintop is reconstructed below (Fig. 3).



Figure 3. View from citadel of the city walls and the enclosed antique city

#### 3.2 Grand Colonnade, Great Tetrapylon and the Triumphal Arch

A long colonnaded street (Grand Colonnade) together with the Great Tetrapylon and the Triumphal Arch are among the most prominent features of Palmyra. Palmyra's Grand Colonnade is one of the best known examples of the colonnaded streets of

Rome in the East. It stretched about 1200 metres from the Damascus Gate to the Temple of Bel. From Greek and Aramaic inscriptions found along it, Gawlikowski established its religious function as a processional road (Gawlikowski, 1977).



Figure 4. Grand Colonnaded Street

Grand Colonnade went through articulation of more than one straight sections. Although the initial aim seems to be going from the Damascus Gate strait to the propylaeum of the Great Temple of Bel, the course had to be redesigned in order not to demolish the Temple of Nabu. The construction which had begun at the north-western end of the city in the early 2<sup>nd</sup> century ran 500 metres in the direction of the temple of Bel and had to skirt around the Temple of Nabu which was built in the 1<sup>st</sup> century (Ball, 2014). It had to change its alignment once more before reaching the Temple of Bel (Fig. 4).

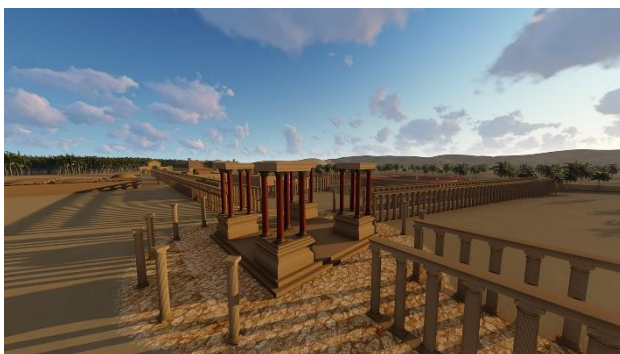


Figure 5. Great Tetrapylon

The first change of alignment was marked with the Great Tetrapylon which was erected at the centre of a circular piazza. It was also at the crossroads where another colonnaded street from the south joined the Grand Colonnade. Thus the Great Tetrapylon was built to provide an urban focal point at the intersection of not two but three colonnaded streets. The complex was composed of four tetrapylons which appeared overall as four separate structures. Each tetrapylon consisted of four columns which were made of red Assuan granite of length 10.65 metres, including bases and Corinthian capitals. They were topped by a solid cornice. The overall height was 16.42 metres (Fig. 5).

Grand Colonnade used to end on Eastern side with the Triumphal Arch (or Monumental Arch). It was built in the 3<sup>rd</sup> century and was an outstanding example of the Palmyrene art and architecture until obliterated in October 2015. Architectural it consisted of a monumental decorated gateway in the center which was flanked

by smaller openings on each side. The structure was decorated with ornate stone carvings (Fig. 6)



Figure 6. Triumphal Arch

### 3.3 Temples

Of the many temples which Palmyra boasted none are visible today. Two temples, those of Bel and Baalshamin used to be partly erect until they were flattened in the summer of 2015. In earlier works reconstruction of them were presented (Denker 2016 and Denker, 2017). Due to their low state of preservation temples of Allat, Nabu, Funerary sanctuary and Flag sanctuary were left alone by Isis at the beginning. Funerary Temple had a well preserved portico. In subsequent waves of vandalism it also fell. Thanks to the excavations of Polish and Syrian teams sufficient information had been compiled about the temples of Allat and Nabu as well as the Funerary and Flag Sanctuaries. Relying on this information, reconstruction attempts had been expanded to include those less known temples. In this section the restitution results of the less known temples are presented, in addition, new render results are presented about Temples of Bel and Baalshamin.

#### 3.3.1 Temple of Allat

Allat was a warrior goddess who occupied an important place in the pantheon of Palmyra. Her worship was attested for the first time by Herodotus, then by the figures and inscriptions which were spreaded all over Syria. An honorary inscription which was found by the Polish team under the leadership of K. Michalowski, definitively confirmed the equivalence of Allat to Athena thanks to her warrior-like aspect. Temple of Allat was located at the western end of Palmyra in a region which is called Dicleotian Camp but it was older than the camp.



Figure 7. Temple of Allat



The first sanctuary was built towards the end of the first century. In the later sanctuary of the second century the architect had respected the original design which looked Hellenistic outside and traditional inside. The cella was in the middle of a rectangular temenos, lined with pillars. The entrance to the sacred courtyard was guarded by a monumental lion. The lion's awesome mouth was open with a fearsome posture, but at the same time he was portrayed as protecting an antelope between his paws (Colinet, 1995). It was symbolised with this statue that Allat would bless those who do not shed blood. The lion which decorated the entrance to the Palmyra Museum courtyard was demolished in 2015. The reconstruction was done after the drawing of A. Ostraz and M. Baranski (Fig. 8)

### 3.3.2 Temple of Nabu

The temple of Nabu is situated along the colonnaded street at a location just before the sacred road takes its final bend in order to reach the Great Temple of Bel. This road section was probably altered in order not to damage the temple. The back side of the temple is opposite the colonnaded street, and the front side looks at the wadi. Nabu was closely associated with Bel. In Babylonia he had acquired a great renown as the son Bel (Bouinni 1976). Due to high ranking of Nabu, the Temple of Nabu was the second largest sanctuary in Palmyra after the Bel Temple. This temple was designated as 'Corinthian Temple' in the book of Theodor Wiegand (Wiegand 1932). It was laid bare by a team of Syrian Archaeologists in 1970. Several Palmyrenic inscriptions to Nabu pointing to "the good and rewarding (or revenant) god", allowed a definitive identification of the sanctuary. It was erected in the last quarter of the 1<sup>st</sup> century and consecrated to God Nabu. The team leader was A. Bounni, he authored a plate book in 1992 (Bounni et al, 1992) which was followed by a text book 12 years later (Bounni, 2004). Although the temple was levelled in 273 AD, thanks to a number of preserved fragments of the architectural elements, a reliable reconstruction of the sanctuary had been possible. Were it not for the information given in these books about the architecture of the Temple of Nabu and the reconstruction drawing, the 3D model presented in Figure 8 would not have been possible.



Figure 8. Temple of Nabu

The reconstruction shows a sanctuary within an irregular trapezoidal court with a monumental entrance on its southern side. The cella rises on a podium of 2,15 m height. It is oriented north-south and opens in south direction against the propylaea. Its peristyle measures 20 to 9 m and is surrounded by 32 Corinthian columns. The cella is covered with a flat terrace and crowned by a wreath of steams. Inside the cella there is an adyton (thalamos) which is flanked by two stair-towers. This is a familiar form in Palmyrene temples like the Temple of Bel.

### 3.3.3 Funerary Temple

Funerary temple is also known as tomb number 86, based on the catalogue of M. Gawlikowski (Gawlikowski,.....). It was erected at the west end of the colonnaded street. The date of the building is believed to be late 2<sup>nd</sup> century or early 3<sup>rd</sup> century. There is a conviction that it should have belonged to one of the royal families. In Figure 9. The shrine is featured with a view of its façade which used to have a well preserved entablature supported by six Corinthian columns. Its picturesque position with the citadel as a backdrop is reflected under the lighting of the setting sun.



Figure 9. Funerary Temple

### 3.3.4 Temple of Baalshamin

Temple of Baalshamin, together with Temple of Bel was one of the two best known and most well-preserved temples of Palmyra. It was the first monument of the antique city which fell victim to remorseless vandalism in August 2015. Baalshamin was the "Lord of Heavens." The first construction of the temple dates to 2<sup>nd</sup> century BC. From an inscription which was found in the temenos it was attested that the temple was rebuilt in 131 AD when Emperor Hadrian came to visit the city (Texidor, 2015). The temple was known to the western world in 1753, thanks to the drawing of Giovanni Battista Bora in R. Wood's book (Wood, 1753). A second and even more ambitious record of the monument resulted from the visit of French artist Louis François Cassas in 1785 (Cassas 1900). In 1864 the temple was photographed for the first time by the French photographer Lois Vignes. The first archaeological treatise of the temple was compiled by T. Wiegand which included an architectural drawing of the temple by his team (Wiegand, 1932). Excavations of the Swiss archaeologists also added invaluable information to our



Figure 10. Temple of Baalshamin

repertoire. In Figure 10, a reconstruction of the Temple of Baalshamin is shown against the backdrop of Qalaat Shirkuh mountaintop.

### 3.3.5 Temple of Bel

The magnificent temple of Bel was the most impressive and best preserved monument of Palmyra. It was consecrated to Bel during the reign of Emperor Tiberius in 32 B.C. the most holy of the deities of Palmyra. Bel was the omnipotent God of Palmyra. He was the creator of the astronomical heaven, like the Greek Zeus, the king of the gods, whose symbol was the planet Jupiter. Bel was not a sun god but a cosmic god. He had originated from the great god of Babylon, Bel-Marduk. He was not the only God who was worshiped in his temple; two other gods were with him as subordinates: Sun god, Yarhibol and the Moon god Aglibol, meaning the three divinities formed a triad (Seyrig, 1950).



Figure 11. Triumphal Arch and the Propylaeum of the Temple of Bel at the backdrop.

Visitors used to be directed to the monumental propylaeum of the temple at the Eastern end of the Grand Colonnaded Street by the Triumphal Arch (Fig. 11). This propylaeum was preceded by a portico supported by 10 Corinthian columns two of which were forming pairs at the inner sides. A grove of palm trees was encircling the teens at the backdrop and a stream was skirting its southern flank (Fig. 12).



Figure 12. The Great Temple of Bel from outside.

The cella was a pseudo-dipteral building, it stood asymmetrically (slightly east of centre) in a temenos of 205 metres by 210 metres. Porticos with Corinthian columns surrounded the temenos. The entrance to the cella was through a richly decorated portal which was opened on the western flank of the peristyle, unlike traditional Greco-Roman Temples. The Corinthian columns of the peristyle were topped with bronze capitals which were plated

with gold. The overall appearance of the temple was reflecting the wealth and might of the period it was constructed (Fig. 13)



Figure 13. Triumphal Arch and the Propylaeum of the Temple of Bel at the backdrop.

## 4. PUBLIC BUILDINGS

### 4.1 Diocletian Camp

With the visit of Emperor Hadrian to Palmyra (AD 130-131) its status was reinstated as a Roman city. This status of Palmyra was also emphasized during the reign of Emperor Diocletian (AD 284-305). The region called as the Diocletian Camp which was established at the western end of the acropolis was constructed by Sosianus Hierocles, Diocletian's governor of Syria. A Polish Archaeological team, led by K. Michalowski excavated the site. Two buildings which stood out at the site were Temple of Allat (See 3. 3. 1) and Flag Sanctuary. Flag Sanctuary was built between 293 and 303 A.D. It was Roman legion's principia and served functions such as barracks for accommodation of troops and storage of weapons.



Figure 14. Two outstanding buildings of the Diocletian Camp: Temple of (Front) and Flag Sanctuary (Rear).

### 4.2 Diocletian Baths

This site is another of the public buildings which were constructed by Sosianus Hierocles. It was situated near the colonnaded street and to the north-east of the Temple of Nabu. The portico of the baths was opening to the colonnaded road. The construction of this bath complex for the dwellers of Palmyra away from the wadi through which the stream was supposedly flowing may be taken as an indication that either there were other sources of water supply or baths received water via water



channels from the stream. The Syrian excavations of 1959-60 gave some tangible information about the architecture of the building. It was built after the classical architectural lines of Roman baths with a central pool, small bathing compartments and separate sections of *caldarium* and *frigidarium* for hot baths and cooling respectively. The reconstructed complex of baths is shown below in Figure 15.

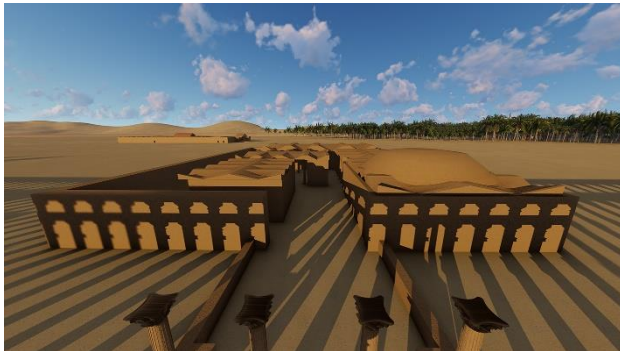


Figure 15. Diocletian Baths

#### 4.3 Agora

For a caravan city like Palmyra the role Agora played is apparently significant. It was constructed near the theatre and between the Colonnaded Road and the stream. The water received from the stream via water channels was flowing through the fountains of agora which were placed in two corners of the court. Agora covered an area of 70m by 82m, the court was surrounded by porticoes which consisted of 80 Corinthian columns.



Figure 16. Agora

#### 4.4 The Theatre

The theatre of Palmyra is a building which has a totally Roman form. It is located to the west of the Temple of Nabu and south-east of Tetracylon. The amphitheatre is a horseshoe-shaped building with a cavea of 92 meters in diameter and an adjoining portico. It was surrounded by a ring-shaped area of 104 X 82 m. This expansive area had been very likely to be used both by the visitors of the theatre and of the caravan dealers who were coming to market their merchandise at the Agora. This area was excavated in (1959-1962). It was buried by then under 5 m high sand. It was brought to daylight only after several thousand tons of rubble and sand were removed especially in the western and north-western areas (Fig. 17).

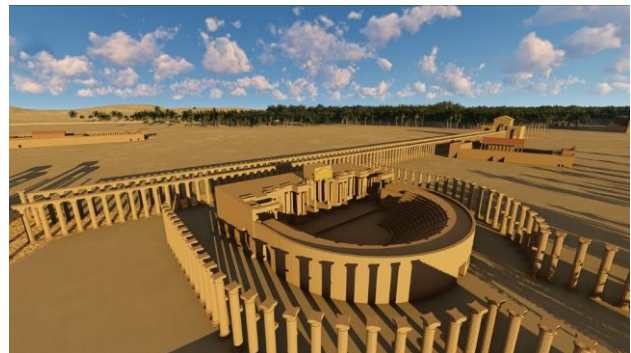


Figure 17 The Theatre

### 5. NECROPOLIS

Tower tombs spreading around a vast necropolis used to be the extant manifestations of the richness of Palmyra, in the 2<sup>nd</sup> and 3<sup>rd</sup> centuries. Situated at the skirts of the mountain range, they reflected with murals and expressive portrait paintings the prosperity of the merchant class of the city. Tower tombs of this necropolis were funerary monuments appearing in polygonal shapes and at modest heights on desert surface. They used to stand out as reminders of the after-life. Best preserved of them became the target of Isis and were blown up in September 2015.

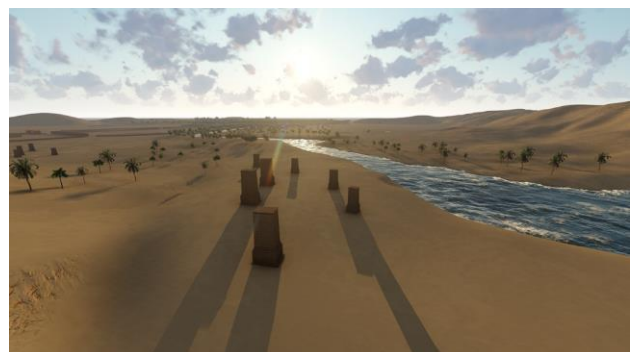


Figure 18 Tower Tombs

### 6. ANTIQUE CITY OF PALMYRA: INTEGRATION OF LANDMARKS AND LANDSCAPE

Palmyra was a site of outstanding value from aesthetic, cultural and historical points of view. Landmarks of Palmyra comprised a number of temples, hundreds of metres of colonnaded streets, a Roman theatre, a citadel, and an agora in addition to innumerable tomb towers, plus an ancient city wall encircling a major part of them.

These cultural heritage monuments can only be understood, if the surrounding landscape is taken into account, as well. City itself had developed along caravan routes and in the neighbourhood of a stream. Integration of the landmarks of Palmyra with the terrain required the combination of separate 3D models of the landmarks with the model of the landscape. This stage of visualization was imperative for the reconstructed city to accurately represent its now demolished counterpart in reality. It is at this stage that not only the monuments but the entire city of Palmyra has been brought back from rubble, by using the techniques of virtual reality.

The reconstructed individual models of the temples and other landmarks of Palmyra have been pieced together with the 3D environment to form the virtual model of Palmyra as a whole. The topographical model of the landscape was covered with the natural fauna and vegetation. Its “pleasant streams” as described by Pliny were also added.

With the illumination effects of sun setting and the walls of the temples turning gold and pink in the desert light, the reconstructed antique city of Palmyra makes one feel a deep connection across the centuries to the city’s heydays in the 2<sup>nd</sup> and 3<sup>rd</sup> centuries

Special topographic features had determined where the Great Temple of Bel was erected. It was enveloped by a grove of palm trees neighbouring the stream, and on top of a low hill commanding the view of the city (Fig.19). Similar features were sought in choosing the locations of other divine buildings such as the Temple of Baalshamin, Temple of Nabu, Temple of Allat, etc. Sovereigns, as well as wealthy and mighty families chose special places like the valleys at the mountain range to erect their tower tombs.



Figure 19. Flying over the Temple of Bel

Since this landscape is in an area of war, a safe journey to the place is only possible via a virtual visit through a digitally created landscape model of the region. In order to reconstruct the morphologic features of Palmyra’s landscape, elevations of topographic surface were modelled by the contour lines from existing maps of the region.

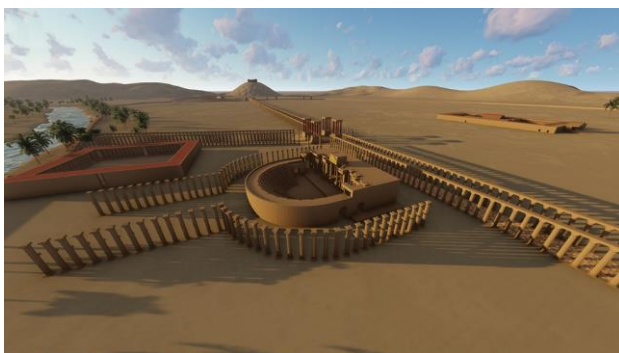


Figure 20. Flying over the theatre and Agora

Since the contour lines are representations of smooth transitions between points, in places where sharp edges are present they may be inadequate, and need to be complemented by other methods of measurements (e.g. tachometric measurements such as LIDAR, IFSAR, stereo photogrammetry, aerial and land surveys etc.). However, the region surrounding Palmyra was composed

of formations with smooth features and in the absence of terrain roughness, existing topographic maps with contour lines were adequate for obtaining the Digital Surface Model (DSM) of the real terrain. By draping texture images over the DSM of the terrain visualization of the terrain was completed.



Figure 21. Flying over Tetrapylon.

In this project where such a large number of landmarks were involved over an area of 50 km<sup>2</sup>, the task of landmark-landscape integration turned out to be a huge task. In order to bring the demand on CPU and GPU down to manageable sizes of expenditure, landmark geometries had to be between complete models and reduced models.



Figure 22. Flying over the City Centre.

Reduced models kept typical features by stripping the complete models of details such as embellishments and decorations.



Figure 23. Sunset over Palmyra

Subsequent to this reduction in geometries of the landmarks, a virtual flight over the antique city of Palmyra was enabled. The overall feeling of the antique city was reflecting the wealth and prosperity of the period it was at its peak (Figs. 19-23).

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